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EXPERIMENTAL INVESTIGATIONS OF EFFECT OF HEATED ABRASIVES ON ABRASIVE JET COATING REMOVAL RATE ON THE SOFT BASE MATERIALS

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ABSTRACT

Coating removal is an important process during the recondition and recoating process of ship base section, bigger structures, marine components, windmill wings and other engineering components. It is essential to remove and clean the existing painting and coating before repainting. The improper and uneven coating removal leads to higher stress concentration. The surface quality of a coated removed surface is critical as it leads to various failures [2].

This work deals with the development of abrasive jet nozzle and fabrication of heated abrasives for coating removal [5]. An experimental setup will be designed and developed in order to investigate the effect of a stand of distance,the temperature of abrasive and an exit diameter of the abrasive jet nozzle on coating removal rate.[6]

Abrasives such as SiC, Garnet have commonly used abrasives for achieving a smooth finish with higher material removal rate. Coating removal will be taken place as the abrasives impinge on the surface of the work -piece [7]. When the heated abrasives strike the surface, due to the high temperature of the abrasives it was found that the coating is separated from the surface and there is an increase in material removal rate (MRR).

KEYWORDS: Abrasive Jet, Heated Abrasives, MRR & Coating Removal

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Original Article

INTRODUCTION

This process carries a stream of compressed air with heated abrasive particles is focused on a surface to remove coating [5]. Its advantages are, coating removal due to the generation of heat between interference, can be used for more hardened surface, no tool required, can be used for any intricacies, no cutting forces and can be used for very small wall thickness. The coating removal rate and the surface roughness are a function of speed, temperature, the grain size of abrasives, pressure, and stand of distance. Literature study reveals the various influencing parameters for abrasive machining process for various operations like cutting, drilling, and deburring cleaning etc. for different types of materials [1]. It also shows that how the productivity of the abrasive blasting can be increased by operating at design pressure, designing an effective nozzle, using very small sized abrasive particles [2]. It also shows that the Material removal rate can be increased by heating the abrasives [5].

MODELING OF MATERIAL REMOVAL

Material removal in AJM takes place due to brittle fracture of the work material and the impact of high -velocity abrasive particles [2].

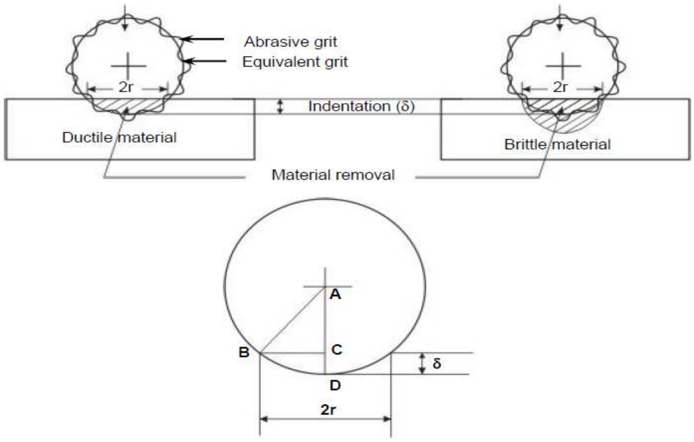

Figure 1: Illustration of Interaction of Abrasive Particles with Work Piece

Modelling has been carried out by considering that abrasives are spherical in shape and rigid, the particles are characterized by the mean grit diameter, the kinetic energy of the abrasives are fully utilized in removing material, brittle materials are considered to fail due to brittle fracture and the fracture volume is considered to be hemispherical with diameter equal to the choral length of the indentation. For ductile material, removal volume is assumed to be equal to the indentation volume due to particulate impact [4].

Metal Removal Rate (MRR) in AJM of brittle and ductile materials can be expressed as [3]

$$MRR_D = \Gamma_D N = \Gamma_D \frac{6\dot{m}_a}{\pi d_g^3 \rho_g} = \frac{\pi \delta^2 d_g 6\dot{m}_a}{2\pi d_g^3 \rho_g} \qquad MRR_B = \frac{4\dot{m}_a v^{3/2}}{6^{3/4} \rho_g^{1/4} H^{3/4}} \approx \frac{\dot{m}_a v^{3/2}}{\rho_g^{1/4} H^{3/4}}$$

Experimental Setup of Heated Abrasive Jet Coating Removal

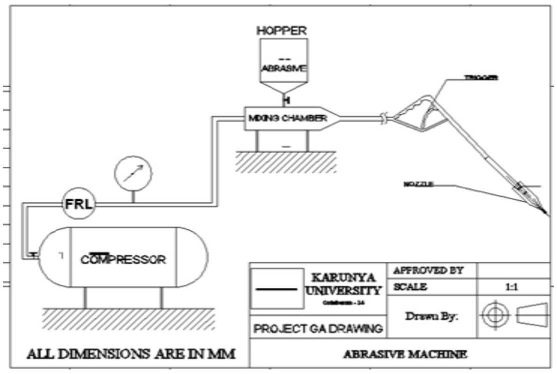

Figure 2: Experimental Lay-Out

Figure 3: Experimental Set-Up

Specifications

Hopper is a 36cm diameter, 50cm length and 1.5m height from ground level. The temperature kept 100 to 300^0 C,the Pressure range of 6 to 8 bars, Compressed Air tank capacity is 220lit.

The experimental setup is shown in Figure 2 & 3, the hopper is connected to the mixing chamber using a 12.3mm diameter mild steel pipe. The nichrome wire of 1 mm diameter and 20 meters of length insulated with ceramic beads, is wound on the hopper. Over the nichrome wire, glass wool is rolled which acts as insulation, i.e. prevention of heat escaping to the atmosphere. The flow of the abrasives is controlled by using a flow control valve. The air from the

compressor is supplied to the mixing chamber using a tube which can withstand a pressure of 20 bar. The air and abrasive get mixed in the abrasive chamber and comes out through an outlet of 12 mm. From the mixing chamber the abrasives are sent through Teflon hose which can withstand heat of about 400 °C. A Butterfly valve is provided with the gun to control the flow of abrasives. The nozzle is attached to the other end of the gun. In this experiment, two nozzles are used 6mm and 8mm nozzle. Suitable arrangements are provided for quick replacement of nozzles.

The abrasives of required mesh size are fed into the hopper and they are heated to the required temperature. A thermostat is provided to control the temperature of the heater and a thermocouple to measure the heat inside the hopper. When the required temperature is reached the abrasive is let down to the mixing chamber where it is mixed with air which is passed at the required pressure. The mixture is sent out through the nozzle strikes and removes the material of the workpiece. The horizontal movement of the gun is provided by using AC motor. The feed rate is kept as constant and the material removal rate by changing the parameters such as pressure, a stand of distance and temperature is investigated.

EXPERIMENTATION

Stand of Distance (SOD) and Materials Used for Investigations

A stand of distance is the distance between the nozzle tip and the workpiece. By varying the SOD, the material removal rate found out. An aluminum sheet of 5mm thick used as a specimen of constant area 20mm×20mm. Garnet was selected as the abrasive material for experiments. Garnets of three different mesh sizes are used for the experiments. The Material Removal Rate by varying the Pressure, Temperature, Stand of Distance and Size of abrasives are noted.

RESULTS AND DISCUSSIONS

The pressure of abrasive stream has been set as $20x10^5 N/mm^2$. The abrasive mesh size, nozzle diameter, pressure has been selected as 60, 80 and 120 mesh, 6mm &8mm, 6bar and 8bar respectively. The Stand of Distance (SOD) has been varied from 20mm to 40mm in the step of 10mm. The temperature of abrasives has been varied from atmospheric temperature to 300°C in the step of 100°C and the Material Removal Rate (MRR) was evaluated for each experimental condition.

- **Effect of SOD and the Heated Abrasives on Material Removal Rate (MRR) when Nozzle Diameter 6mm and Abrasive Size is 60 Mesh**

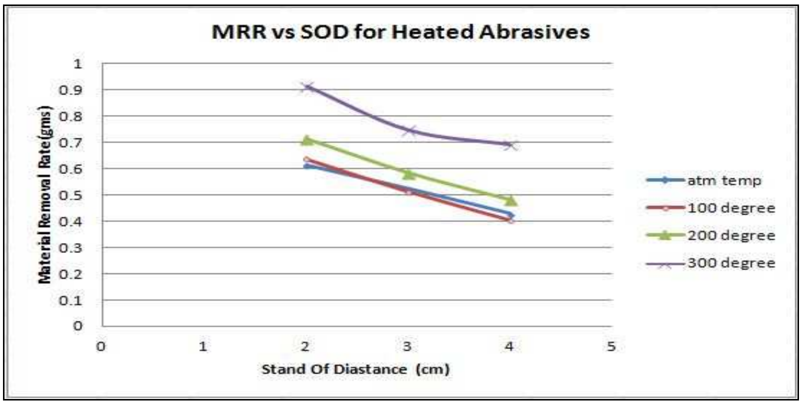

Figure 4: Effect of SOD and Heated Abrasives on MRR When Abrasive 60 Mesh, 6mm Nozzle, 6 Bar Pressure

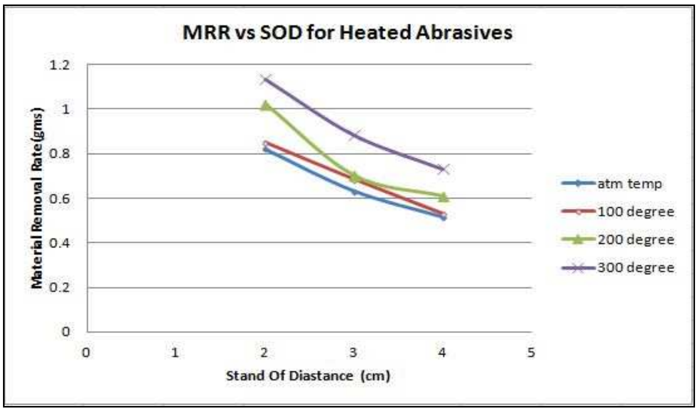

Figure 5: Effect of SOD and Heated Abrasives on MRR When Abrasive 60 Mesh, 6mm Nozzle, 8 Bar Pressure

Figure 4 clearly shows as the temperature of abrasives increases to 300°C, the MRR is higher at a SOD of 20mm. MRR increases from 0.7g/s to 0.9g/s. The Figure 5 shows that pressure also plays a significant role in material removal rate. At 8 bar pressure, the MRR is high when compared to the previous graph. MRR increases from 0.78g/s to 1.1g/s.

- **Effect of SOD and the Heated Abrasives on Material Removal Rate (MRR) when Nozzle Diameter 8mm and Abrasive Size is 60 Mesh**

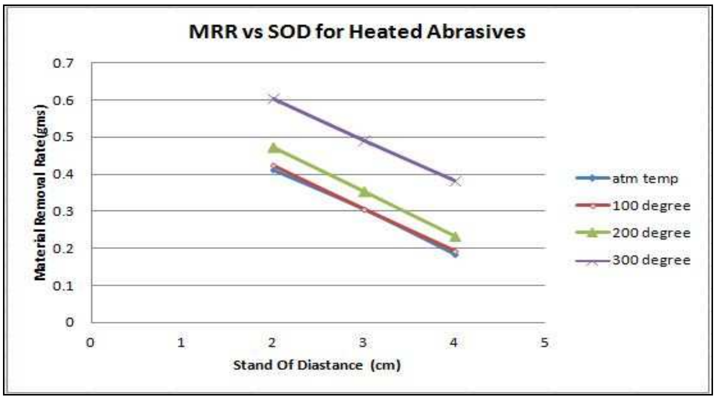

Figure 6: Effect of SOD and Heated Abrasives on MRR When Abrasive 60 Mesh, 8mm Nozzle, 6 Bar Pressure

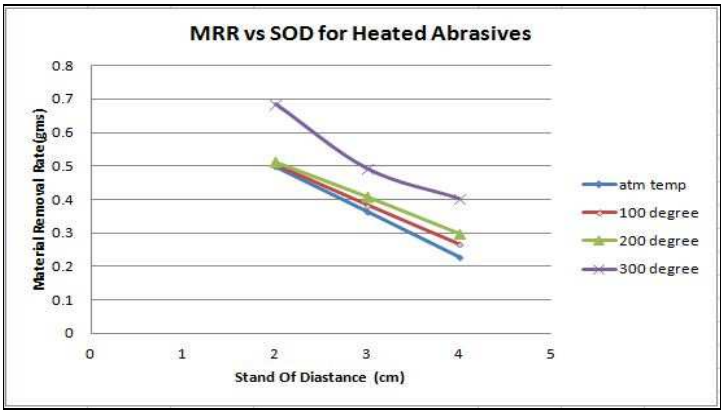

Figure 7: Effect of SOD and Heated Abrasives on MRR When Abrasive 60 Mesh, 8mm Nozzle, 8 Bar Pressure

From the Figure 6, it is noted that there is a decrease in material removal rate due to increases in the diameter of the nozzle. MRR decreases from 0.6g/s to 0.4g/s. Figure 7 shows that there significant amount of material removal when compared to the previous case. MRR increases up to 0.7g/s because of higher pressure.

- **Effect of SOD and the Heated Abrasives on Material Removal Rate (MRR) when Nozzle Diameter 6mm and Abrasive Size is 80 Mesh**

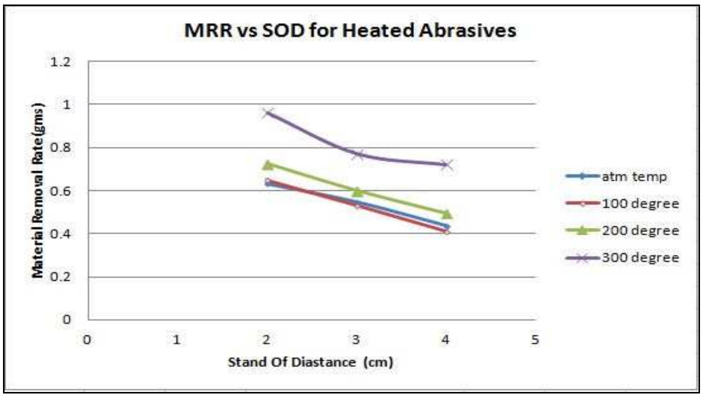

Figure 8: Effect of SOD and Heated Abrasives on MRR When Abrasive 80 mesh, 6mm Nozzle, 6 Bar Pressure

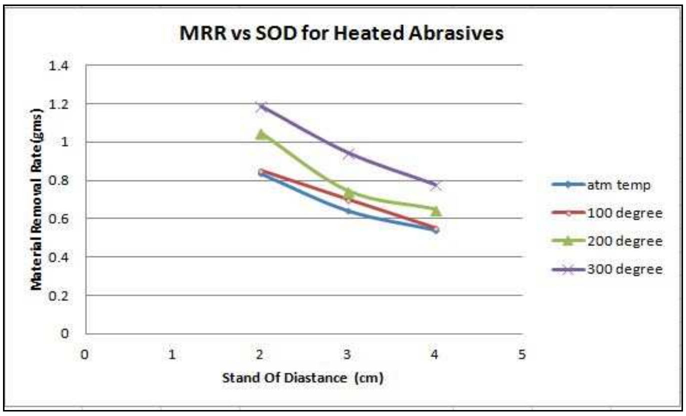

Figure 9: Effect of SOD and Heated Abrasives on MRR When Abrasive 80 Mesh, 6mm nozzle, 8 Bar Pressure

From the above graph, Figure 8 it is noted that the material removal rate is high when compared to previous graphs. MRR increases up to 0.9 g/s because of the smaller size of the abrasives. The above graph, Figure 9 shows that the material removal rate is higher, up to 1.2g/s due to the smaller size of the abrasives and increase in pressure.

- **Effect of SOD and the Heated Abrasives on Material Removal Rate (MRR) when Nozzle Diameter 8mm and Abrasive Size is 80 Mesh**

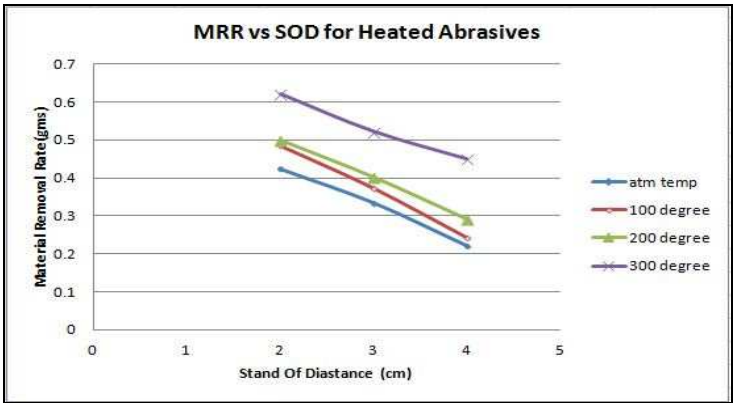

Figure 10: Effect of SOD and Heated Abrasives on MRR When abrasive 80 Mesh, 8mm Nozzle, 6 Bar Pressure

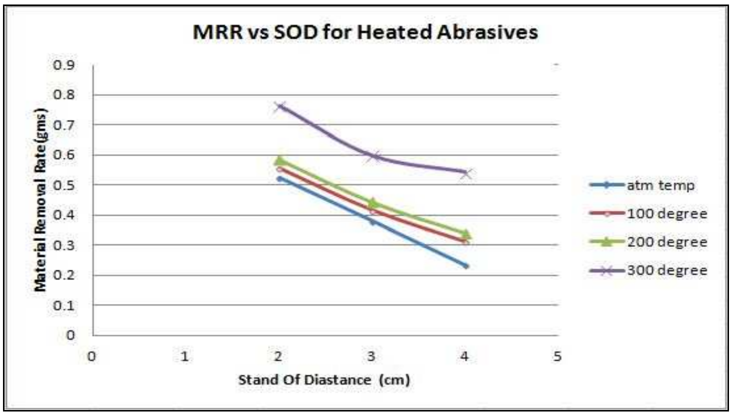

Figure 11: Effect of SOD and Heated Abrasives on MRR When Abrasive 80 Mesh, 8mm Nozzle, 8 Bar Pressure

From the Figure 10, the material removal rate is maximum (0.6g/s) at 300°C and minimum (0.2g/s) at an atmospheric temperature at a SOD of 40 mm. Figure 11 denotes that there is no significant change in material removal rate at atmospheric temperature and 100°C.

- **Effect of SOD and the Heated Abrasives on Material Removal Rate (MRR) when Nozzle Diameter 6mm and Abrasive Size is 120 Mesh**

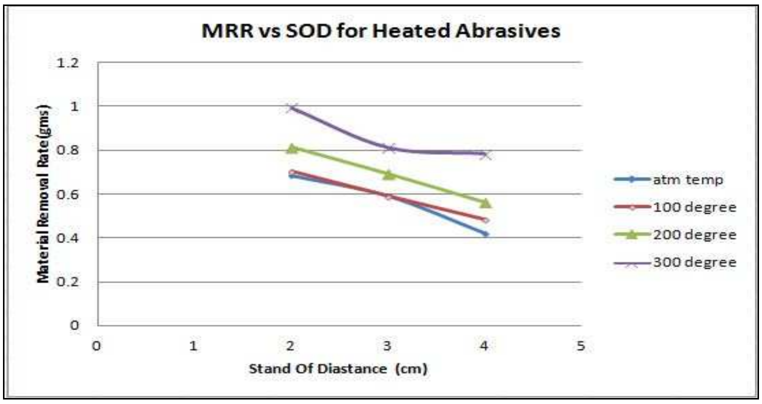

Figure 12: Effect of SOD and Heated Abrasives on MRR When Abrasive 120 mesh, 6mm Nozzle, 6 Bar Pressure

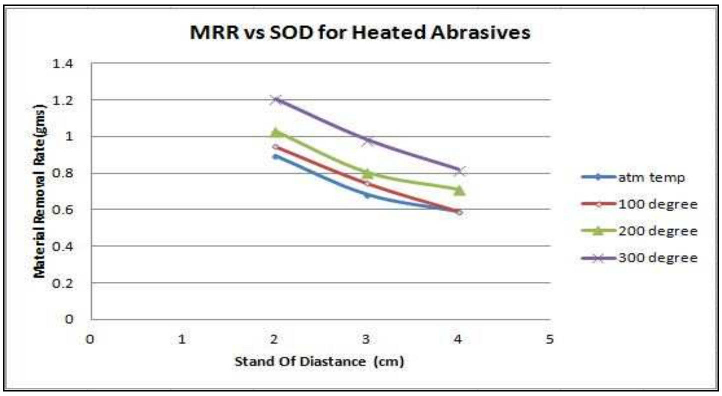

Figure 13: Effect of SOD and Heated Abrasives on MRR When Abrasive 120 Mesh, 6mm Nozzle, 8 Bar Pressure

Figure 12 shows that the mesh size determines the material removal rate. Material removal is higher (1g/s) due to smaller size of120 mesh abrasives. Figure 13 shows that the highest material removal rate is noted when smaller mesh size and the smaller nozzle is used. The highest material removal rate (1.2g/s) is observed at 300 °C at a stand of distance 20mm.

- **Effect of SOD and the heated abrasives on material removal rate (MRR) when nozzle diameter 8mm and abrasive size is 120 mesh**

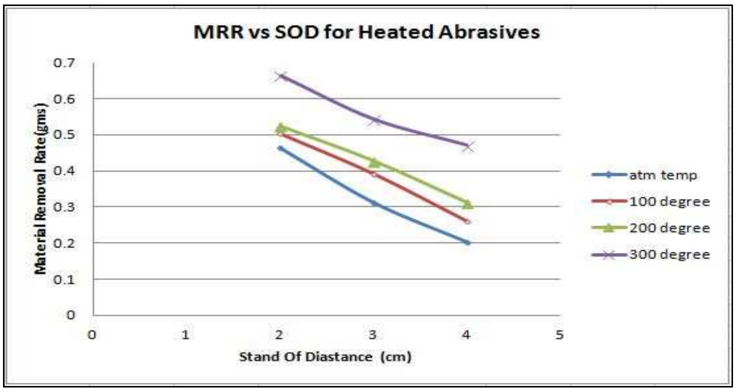

Figure 14: Effect of SOD and Heated Abrasives on MRR When Abrasive 120 Mesh, 8mm Nozzle, 6 Bar Pressure

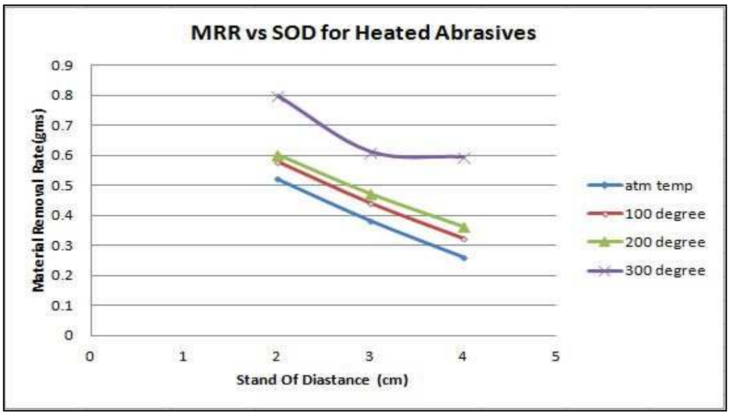

Figure 15: Effect of SOD and Heated Abrasives on MRR When Abrasive 120 Mesh, 8mm Nozzle, 8 Bar Pressure

From Figure 14, the material removal rate decreases from 0.7g/s to 0.45g/s as the Stand of Distance increases from 20mm to40mm. Figure 15 shows that the material removal rate is maximum(0.8g/s) at 300 °C at a Stand of Distance of 20mm and it is minimum(at atmospheric temperature) at a Stand of Distance of 40mm. As the SOD increases, the travel distance also increasing and there will be a loss of energy of abrasives. This leads to the reduction in MRR.

CONCLUSIONS

The effect of heated abrasives, stand off distance (SOD), abrasive size and applied pressure on material removal rates (MRR) have been investigated by conducting various experiments.

The heated abrasive was produced by fabricating a chamber with the heating arrangement. The investigation reveals that as the temperature of the heated abrasives increases from 100°C to 300°C, the MRR also increases. The higher MRR has been obtained by using heated abrasives with 300°C.

To investigate the effect of SOD on MRR, the SOD was varied from 20mm to 40mm and it was observed that 20mm SOD promotes higher MRR than30mm and 40mm SOD. The investigations revealed that, the heated abrasives were very effective in coating removal and the mesh size of the abrasives, nozzle diameter and pressure also have an influence on MRR.

The mesh size of abrasives also plays a major role in improving the MRR. The experiments clearly show that as the abrasive mesh size increased from 60 to 120, there is an increase in MRR and the abrasive size 80mesh provides more MRR. The analysis also shows that, as the pressure increases to 8bar, there is an increase of MRR. This is due to, a small particle is accelerated at higher speed and which leads to higher material removal rate.

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